SIGCSE Special Projects Grants

Final Project Report

Application Date:	9/21/2014
Applicant Name(s):	Alessio Gaspar & Amruth Kumar
Institution:	University of South Florida, Tampa, FL Ramapo College of New Jersey, Mahwah, NJ
Postal Address:	3433 winter lake road, 33803, Lakeland, Florida 505, Ramapo Valley Road, Mahwah, NJ 07430-1680
Email Address:	alessio@usf.edu amruth@ramapo.edu
SIGCSE (ACM) Membership Number:	Alessio – 3258007 Amruth – 3694635
Project Title:	Assessing the potential of Evolved Parsons Puzzles as compared to their instructor-designed counterparts

Brief Project Description Appropriate for the SIGCSE Website (under 50 words):

This project aims at extending the Problets programming tutor so as to handle both instructor-designed and autonomously evolved Parsons Puzzles. The software will be used to conduct a comparative study of both approaches based on students-problems interactions logs and attitudinal surveys.

Amount Requested in U.S. Dollars:	$4,800
Amount funded	$3,650

Final Project Report

Summary of Project' Proposal

The following is extracted from our original proposal in order to provide an outline for this final project report.

Overall Goals

We aim at exploring a novel approach to autonomously generate programming practice problems. To this end, we propose to;

- Extend the Problets.org software tutor in order to benefit from its existing user base and already demonstrated ability to leverage problem-solving to teach programming.
- Integrate Parsons Puzzles in Problets.org. Parsons Puzzles present students with shuffled fragments of a valid program's source, its requirements, and bugged fragments – "distractors". They require students to select appropriate fragments to reconstitute the original program.
- Apply Evolutionary Algorithms to evolve Parsons Puzzles. EAs generate an initial population of random potential solutions, iteratively modify those using "evolutionary operators", and propagate above-average solutions, until convergence.

Together, these outcomes will allow us to provide students and instructors with a new type of practice problems readily usable in Problets.org. They will also allow us to establish the feasibility of automatic generation and assess the efficacy of hand-designed Parsons Puzzles from that of their evolutionary counterparts by comparing usage logs. This work is also essential in building sufficient evidence to prepare NSF IUSE or Cyberlearning proposals to further extend our results through nationwide active dissemination and evaluation efforts.

Expected outcome

Our first outcome is to extend *Problets.org* to support both instructor-designed and evolved Parsons Puzzles. We will then analyse their differences in term of;

- Objective quantitative differences; e.g. descriptive statistics on number of attempts needed for both kind of Parsons Puzzles
- Objective qualitative differences in the design of the two kind of Parsons Puzzles; as identified by instructors reviewing instances of particularly easy or difficult ones.
- Subjective quantitative differences in the ordinal Likert ratings of the perceptions of relevance or usefulness of each type of Parsons Puzzles; as expressed via attitudinal surveys prompting students and instructors to rate samples of both kind of Parsons Puzzles

Start date and duration

The project will start 1/15/2015 and conclude with the presentation of our results at SIGCSE 2017.

Project Activity Summary

We provide a timeline of the project's activity, including the various students that were hired thanks to our award and those who worked on the project as part of their degree completion requirements.

Objective #1 – Adding Parsons Puzzles to Problets.org (Amruth Kumar)

- During Spring 2017, Amruth Kumar submitted a grant proposal titled "Collaborative Research: Promoting Algorithmic Thinking and Addressing Misconceptions among Novice Programmers" to the National Science Foundation IUSE program. The proposal was not funded.
- Amruth Kumar submitted two papers, first to SIGCSE 2017 and later, to ITiCSE 2017:
    - An Implementation of Tutors on Parsons Puzzles and Their Evaluation
    - Analyzing Parsons Puzzle Logs for Algorithmic Thinking Patterns

  Neither paper was accepted.

Objective #2 – Develop Evolutionary Parsons Puzzles (Alessio Gaspar)

- During fall 2014, Alessio Gaspar designed the necessary Broker architecture to be used to connect the Evolutionary Algorithm with Problets.org and recruited students to work on the project.
- In Spring 2015, Paul Burton, BSIT undergraduate student, did his IT Senior Project on implementing some aspects of the above architecture. This project allowed us to test several possible approaches.
- In summer 2015, Paul Burton was hired as OPS on this grant's budget in order to complete the implementation he started as part of his IT Senior Project.
- Remaining funds were used to then hire Stephen Kozakoff, a MSIT graduate student) to work on finalizing the distributed Java RMI architecture during fall 2015 and then spring 2016 where he dedicated his Graduate Practicum project to this work.
- In parallel to this implementation work, a graduate student, Golam A.T.M. Bari, worked with Alessio Gaspar to prepare a library of programs and transforms. The latter were meant to be used by the Evolutionary Algorithm to generate distracters from the valid programs' fragments.
- In addition, Golam and Alessio have been working on the preliminary validation of the Evolutionary Algorithm that would eventually be used to evolve our Parsons puzzle. This work allowed to gain insights about the characteristics of the problem and its relations with Coevolutionary algorithm commonly used in the literature. It resulted in publications in FLAIRS'16 and ICTAI'16 of "Design Guidelines" to enabled a Coevolutionary Algorithm to be successfully applied to the problem of generating practice problems for students.
- In Spring 2017, the above algorithm has been deployed for the first time on students enrolled at USF in the COP 2512 Programming Fundamentals for IT online course. Two experiments were conducted. First, mid-semester, students interacted with the Evolutionary Parsons puzzle system, hosted at Problets.org. As a result, our system evolved 10 Parsons puzzles after interacting for one week with over a hundred students. At the end of the semester, students were again led to interact with the system but, this time, with only the 10 Parsons puzzles previously evolved. The results of these two experiments allowed us to confirm the previously proposed design guidelines and confirm the benefits of the evolutionary approach. As of summer 2017, a journal article to be submitted to ACM Transaction on Computing Education is being finalized. This paper will review the previously outline design guidelines and provide an analysis the experiments conducted during Spring 2017 in terms of validating our evolutionary approach.
- In Spring 2017, we submitted a NSF Cyberlearning proposal meant to support further explorations of the relations between Coevolutionary dynamics and the automated generation of Parsons puzzles for novice programmers.
- As of Fall 2017, we are ready to disseminate the system on Problets.org to a wider audience. The implementation has been validated and so have the main design guidelines of the evolutionary algorithm. We plan on collecting student-puzzles interaction data during both fall 2017 and

spring 2018. This data will be then used to validate and replicate our initial Spring 2017 experiments on a much larger scale and with a more diversified student population. Results will be submitted to ACM Transactions on Computing Education.

Project Deliverables

As a result of the above discussed activities, the following deliverables are now available;

- Implementation of Parsons puzzles tutors, named "Epplets", available at http://epplets.org/
- Implementation of Evolutionary Parsons puzzles. The system is made available to use via the above website to students and instructors. In addition, the source code is also made available on the project's SourceForge website at https://sourceforge.net/projects/evotutoring/
- Publications on Parsons puzzles tutors (Epplets);
    - Kumar, Amruth N. An Implementation of Tutors on Parsons Puzzles and Their Evaluation. Submitted first to SIGCSE 2017 and later to ITiCSE 2017. Rejected.
    - Kumar, Amruth N. Analyzing Parsons Puzzle Logs for Algorithmic Thinking Patterns. Submitted first to SIGCSE 2017 and later to ITiCSE 2017. Rejected.
- Publications on the Design Guidelines to apply a Coevolutionary algorithm to generate practice problems for learners;
    - Gaspar, Alessio and Bari, A.T.M. Golam and Kumar, Amruth N. and Wiegand, R. Paul and Bucci, Anthony and Albert, Jennifer L. **Evolutionary Practice Problems Generation: Problem Characterization.** 28th IEEE International Conference on Tools with Artificial Intelligence. ICTAI'16, San Jose, CA, USA. Acceptance rate ~30%. Source: Email from Miltos Alamaniotis, ICTAI 2016 Program Co-Chair. Accepted, presented
    - Gaspar, Alessio and Bari, A.T.M. Golam and Wiegand, R. Paul and Bucci, Anthony and Kumar, Amruth N. and Albert, Jennifer L. **Evolutionary Practice Problems Generation: More Design Guidelines.** Proceedings of the 30th International Conference of the Florida Artificial Intelligence Research Society. FLAIRS'16, Key Largo, FL, USA. Full paper – 6 pages. Accepted, presented.
- Publications on evaluating the impact of Evolutionary Parsons puzzles on students;
    - Bari, A.T.M. Golam and Gaspar, Alessio and Wiegand, R. Paul and Bucci, Anthony and Albert, Jennifer L. and Kumar, Amruth N. **Evolutionary Parsons Puzzles: Design, Implementation & Preliminary Evaluation**. To be submitted to ACM Transaction on Computing Education by end of summer 2017.
- NSF Grants submitted to further extend this work;
    - Collaborative Research: **Scalable scaffolding of novice programmers' learning and automated analysis of their online activities**. NSF IUSE. Submitted Fall 2014, Funded. Alessio Gaspar, PI.
    - EXP: Collaborative Research: **Coevolutionary Dimension Extraction of Algorithmic Thinking Patterns from Intelligent Tutoring System Interaction Logs**. NSF Cyberlearning & Future Learning Technologies. Submitted Spring 2017, rejected. Alessio Gaspar, PI.
    - Collaborative Research: **Promoting Algorithmic Thinking and Addressing Misconceptions among Novice Programmers**. NSF IUSE. Submitted Spring 2017, rejected. Amruth Kumar, PI.